Perceptions of Neighborhood Environment, Sense of Community, and Self-Rated Health: an Age-Friendly City Project in Hong Kong

Ruby Yu · Moses Wong · Jean Woo

Published online: 3 December 2018
© The New York Academy of Medicine 2018

Abstract To examine the relationships between perceptions of neighborhood environment, sense of community, and self-rated health, we recruited 1798 people aged 60 years and older living in Hong Kong. With reference to the checklist of the essential features of age-friendly cities developed by the World Health Organization, perceptions of neighborhood environment were assessed using a questionnaire covering physical and social environmental domains, which mapped onto “outdoor spaces and buildings,” “transportation,” “housing,” “social participation,” “respect and social inclusion,” “civic participation and employment,” “communication and information,” and “community support and health services.” Sense of community was measured by the Brief Sense of Community Scale. Self-rated health was assessed by a single question. The relationships between these measures were analyzed using partial correlations, multivariate regression models, and path analyses. The mean age of the participants was 71.7 years; of which 54.3% were women. In multivariate regression models, perceived neighborhood

environments were positively associated with sense of community and self-rated health. Among the domains of perceived neighborhood environment, “transportation” and “respect and social inclusion” were the physical and the social environmental domains most strongly associated with sense of community, respectively. In addition, sense of community accounted for part of the relationship between perceived neighborhood environments and self-rated health. The results of this study support the importance of perceived neighborhood environments for the sense that older person has of one’s community, and self-rated health of older people which may be enhanced through the improvement of neighborhood environments.

Keywords Age-friendly environment · Perceptions of neighborhood environment · Sense of community · Self-rated health · Respect and social inclusion

Introduction

The world’s population is rapidly aging. In response to this, governments are putting efforts on improving older people’s health and well-being. The World Health Organization (WHO) has drawn attention to the importance of making cities “age-friendly” aiming to help people stay healthy and active [1]. In parallel, there is increasing interest in studying the role of neighborhood characteristics in contributing to health and well-being of older people, with many of these studies focusing on physical activity as the pathway through which

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s11524-018-00331-3>) contains supplementary material, which is available to authorized users.

R. Yu (✉) · M. Wong · J. Woo
Jockey Club Institute of Ageing, The Chinese University of Hong Kong, Hong Kong, SAR, China
e-mail: rubyu@cuhk.edu.hk

R. Yu · J. Woo
Department of Medicine and Therapeutics, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong, SAR, China

neighborhood characteristics are related to various health outcomes [2, 3]. A cross-sectional study of 14 cities also found that the environmental quality of neighborhoods such as net residential density, intersection density, public transport density, and number of parks significantly related to increased physical activity [4]. On the other hand, perceptions of neighborhood quality, individual-level psychosocial and socioeconomic statuses were found to operate as pivotal pathways linking objective neighborhood characteristics to self-rated health [5]. It appears that neighborhood environment may influence an individual's perception and sense that one has of one's community, which in turn may impact on some aspects of health and well-being.

Sense of community is a central construct in the field of community psychology, which has been described as "the sense that one was part of a readily available mutually supportive network of relationships upon which one could depend on, and as a result of which one did not experience sustained feelings of loneliness" [6] and "a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members needs will be met through their commitment to be together" [7]. It is a phrase commonly used by sociologist and politicians to characterize the relationship between the individual and the social structure, because sense of community has been shown to be associated with an array of community involvement behaviors such as community participation [8], which are essential for community development [9]. Sense of community has also been related to a range of health outcomes and indicators of well-being, including frailty [10], mortality risks for cancer [11], life satisfaction and loneliness [12], happiness [13], and quality of life [14].

On the other hand, sense of community has been found to be associated with sociodemographic characteristics. Older age [15], female gender [16], married persons [17], Caucasians [18], higher income [19], longer length of residence [20], and home ownership [21] were found to be associated with higher sense of community and sense of belonging. Educational level, however, tended to show inconsistent associations [16, 22]. These sociodemographic factors influence on social factors such as the likelihood of social involvement, social participation, neighboring, social support, and community attachment,

affecting the sense of community and belongingness of residents.

Various physical and social environmental attributes also contribute to sense of community. The degree of urbanization [23], town size [24], community design [25], housing density and quality [26], feelings of safety [14], and neighboring and access to social services have been linked to a sense of community [12], as was walkability [27, 28]. However, an American study found that mixed land use was negatively associated with sense of community in Atlanta, USA. The authors explained that mixed use of environments in Atlanta predominantly comprised of car-dependent retail centers located adjacent to residential areas, which may minimize opportunities for local residents to walk and interact [28]. The conception and measurement of sense of community may vary across cultural and geographical backdrops, contributing to locally distinctive results [29]. In Taiwan, for instance, higher sense of community was found to be associated with older age, among married persons, homeowners, and those who lived with young family members [30]. In Hong Kong, however, sense of neighborhood was not associated to these sociodemographic characteristics at individual and community level [31], but related to social support and quality of life, as well as to the open space allocation in neighborhood [32]. Local researchers found deletion of some items of the long established Sense of Community Index (SCI) necessary and appropriate to the understanding of sense of community in Hong Kong, and highlighted the uniqueness of sociocultural background of this city, as well as the influence of local geographical structure, urbanization form and sociopolitical climate on social recognition and behaviors, and hence on the sense of community [31]. This background makes more empirical local study necessary to clarify the relationship and provide a fuller account of the relationship in different urban settings with different cultural background and socioeconomic make-up.

Identifying and creating supportive environments that foster and strengthen sense of community within residential neighborhoods are important for aging well. Therefore, we utilized the Jockey Club Age-friendly City (JCAFC) project, a community sample of older people aged 60 years and older living in Hong Kong, to examine the inter-

relationships between perceptions of neighborhood environment, sense of community, and self-rated health, a holistic indicator of health [33]. The specific domains or features of the neighborhood environment that contribute to sense of community were also determined. We also attempted to investigate the role of sense of community as an intervening factor connecting perceived neighborhood environment and health.

Methods

Data and Sampling

Data of the present study was drawn from a cross-sectional survey that explored perceptions of age-friendliness in Hong Kong between 2015 and 2017. The survey employed a convenience sampling method and was designed to interview approximately 500 local residents aged 18 years and above from each of the five districts of Hong Kong (Fig. 1), where the whole territory is divided into 18 districts comprising a total of 431 Constituency Areas (CAs) at present. The five districts include Sha Tin, Tai Po, Kwai Tsing, Sai Kung, and North District, which are located in the New Territories of Hong Kong. Considering the geographical heterogeneity in terms of vulnerability and socioeconomic characteristics, 62 out of 125 CAs in the five districts were chosen according to the Social Vulnerability Index (SVI) [34] and the predominant type of housing (private/subsidized/public housing) therein as proxies of socioeconomic status. As such, participants would represent views and opinions from a wide spectrum of local residents, including the most vulnerable elders and those with different socioeconomic profiles. An age-stratified sample was recruited, so that approximately 10% of the participants would be aged 49 years and below, 20% would be aged 50–59, 30% would be aged 60–69, 30% would be aged 70–79, and 10% would be aged 80 years and older. Furthermore, a sex (male-to-female) ratio of approximately 0.8 was set to match with the overall sex ratio of Hong Kong population. Details of the sampling method and survey population have been reported elsewhere [35].

Participants

Participants were community dwellers of Chinese origin, aged 18 years and above, normally residing in the pre-selected sampling sites for not less than six consecutive months at the time of participation in the survey, and able to speak and understand Cantonese at the time of participation; institutionalized persons, foreign domestic helpers, and individuals who were mentally incapable to communicate were excluded. Among this community sample with a total of 2553 participants from the five districts, the present study included those aged 60 years and above ($n = 1798$) in the subsequent analyses. Participants were recruited by placing recruitment notices in housing estates and elderly community centers. Several talks were also given at the centers explaining the purpose and interviews to be carried out. Data were mainly collected by trained research assistants via face-to-face or telephone interviews (88%); a minor proportion (12%) of the relatively literate respondents self-administered the questionnaires with assistance from trained research assistants. All participants gave written consent, and the study protocol was approved by the Survey and Behavioral Research Ethics Committee of the Chinese University of Hong Kong (ethical code 070–15).

Questionnaire

A structured questionnaire was used in the survey, which consisted of two major sections. The first section sought information on the respondents' perceptions of the age-friendliness of neighborhood environments; the second section collected the respondents' individual characteristics, including age, sex, marital status, educational level, type of housing, length of residence, disposable income, economic activity status, use of elderly community centers, sense of community, and self-rated health.

Perceptions of Neighborhood Environment

Participants' perceptions of neighborhood environment were assessed using a tailor-made version of a structured questionnaire developed with reference to the checklist of the essential features of Age-friendly Cities (AFC) developed by the WHO [36]. The questionnaire consisted of 53 items across the eight

Fig. 1 Hong Kong territory and districts covered in the survey

domains [1, 36], covering physical and social environmental domains, which mapped onto outdoor spaces and buildings (9 items), transportation (12 items), housing (4 items), social participation (6 items), respect and social inclusion (6 items), civic participation and employment (4 items), communication and information (6 items), and community support and health services (6 items). Participants were asked to rate the age-friendliness of their neighborhood on each item on a six-point Likert-type scale, ranging from (1) “strongly disagree” to (6) “strongly agree”. Responses to individual items were averaged to produce a mean domain score. Mean scores of all eight domains were calculated only if over half of the domain items had valid responses. The reliability estimate (Cronbach’s alpha) for each domain ranged from 0.65 to 0.84. A score of overall perceived neighborhood environments was calculated if over half of the total items had valid responses. The higher the score is, the more age-friendly neighborhood environment was perceived.

Sense of Community

Sense of community was measured by an eight-item Brief Sense of Community Scale (BSCS) [37], which was designed to assess the dimensions of needs fulfillment, group membership, influence, and emotional connection defined in the McMillan and Chavis model [7]. Items were measured on a five-point Likert scale from (1) “strongly disagree” to (5) “strongly agree”. Total scores were computed by taking the sum of the eight items. Higher scores on the BSCS represent higher degrees of perceived sense of community.

Self-Rated Health

Self-rated health was assessed by a single question “How would you rate your overall health at the present time?” Respondents were asked to rate their overall health on a five-point Likert scale, on which (1) indicated “poor” and (5) indicated “excellent.”

Data Analysis

To examine the associations among perceived neighborhood environments, sense of community, and self-rated health among older people, participants aged 60 years and older were included in this analysis. Continuous variables are presented as mean values and standard deviation, and the categorical variables are presented as number and percentage. First, partial correlations were used to examine the correlations among perceived neighborhood environments (overall and domain-specific score), sense of community (total and domain-specific score), and self-rated health (coded as an ordinal variable: “poor”, “fair”, “good,” “very good,” or “excellent”). Next, binary logistic regression models were performed to assess both the unadjusted (model 1) and the adjusted (models 2–4) associations between perceived neighborhood environments (overall and domain-specific scores) and self-rated health (coded as a binary variable: poor or fair vs. good, very good, or excellent), with model 2 adjusting for demographic characteristics (age and sex), and model 3 adjusting for the covariates included in model 2 with additional adjustments for socioeconomic characteristics (marital status, educational level, economic activity status, and disposable income), and model 4 adjusting for the covariates included in model 3 with additional adjustments for environmental characteristics (type of housing, length of residence, and use of elderly community centers). The correlations of these covariates with perceived neighborhood environments, sense of community, and self-rated health were also examined. Odds ratios (OR) with 95% confidence intervals (CIs) were reported. The above analyses were repeated to assess both the unadjusted and the adjusted associations between sense of community (overall and domain-specific scores) and self-rated health. Third, linear regression models were applied to assess both the unadjusted and the adjusted associations between perceived neighborhood environments and sense of community. Unstandardized regression coefficients and *p* values were reported. Finally, path analyses were used to examine the role of sense of community in the link between perceived neighborhood environments and self-rated health. For these analyses, perceptions of neighborhood environment were split into perceptions of the physical environment and perceptions of the social environment. Standardized regression coefficients were presented within paths. Correlations among the eight domains of perceived

neighborhood environment were also examined. All statistical procedures were carried out using the Windows-based SPSS Statistical Package (version 24.0; SPSS, Chicago, IL, USA), whereas path analyses were carried out using Amos (version 24.0; SPSS, Chicago, IL, USA). A *p* < 0.05 was used to denote significant difference.

Results

Table 1 summarizes the characteristics of the study population. The mean age of the 1798 participants was 71.7 ± 7.59 years; 54.3% were women, 69.2% were married, and 44.3% had some secondary or tertiary education. The mean length of residence was 21.6 ± 13.52 years. The mean perceived neighborhood environments overall score was 3.99 ± 0.66 , and the mean sense of community total score was 30.24 ± 5.07 . For self-rated health, 854 (47.5%) participants rated themselves as fair, while 733 (40.8%) rated as good/very good/excellent.

Table 2 shows the correlation between perceived neighborhood environments, sense of community, and self-rated health. Perceived neighborhood environments overall score and domain-specific scores were positively associated with sense of community total score and its domain-specific scores including “needs fulfillment,” “group membership,” “influence,” and “emotional connection” (all *p* < 0.001). Similarly, perceived neighborhood environments overall score was positively associated with self-rated health (*p* < 0.001). With respect to perceived neighborhood environments domain-specific scores, “outdoor spaces and buildings,” “transportation,” “housing,” “respect and social inclusion,” “communication and information,” and “community support and health services” were positively associated with self-rated health (all *p* < 0.05).

Table 3 shows the results of logistic regression models linking perceived neighborhood environments and self-rated health. Perceived neighborhood environments overall score (OR 1.2, 95% CI 1.01–1.35) and domain-specific scores including “outdoor spaces and buildings” (OR 1.2, 95% CI 1.04–1.34) and “housing” (OR 1.2, 95% CI 1.10–1.33) were positively associated with self-rated health. “Respect and social inclusion” (OR 1.2, 95% CI 1.03–1.27) became significant when age and sex were added as confounders (model 2, Table 3). Additional adjustments for socioeconomic (model 3, Table 3) and environmental characteristics

Table 1 Characteristics of the study population ($n = 1798$)

Variable	Mean $\pm$ SD, n (%) ^a
Age (years)	71.7 $\pm$ 7.59
Age group (years)	
60–69	761 (42.3)
70–79	744 (41.4)
80+	293 (16.3)
Sex	
Men	822 (45.7)
Women	976 (54.3)
Marital status	
Never married	53 (2.9)
Currently married	1245 (69.2)
Widowed	392 (21.8)
Divorced/separated	104 (5.8)
Educational level	
Primary and below	999 (55.6)
Secondary	649 (36.1)
Post-secondary	148 (8.2)
Type of housing	
Public rental	568 (31.6)
Subsidized home ownership	681 (37.9)
Private permanent	524 (29.1)
Temporary/others	23 (1.3)
Length of residence in the community (years)	21.6 $\pm$ 13.52
Disposable income	
Very insufficient	47 (2.6)
Insufficient	295 (16.4)
Just sufficient	1124 (62.5)
Sufficient	283 (15.7)
More than sufficient	45 (2.5)
Economic activity status	
Unemployed	24 (1.3)
Working	132 (7.3)
Retired	1411 (78.5)
Homemaker	219 (12.2)
Others	6 (0.3)
Use of elderly community centers	
Yes	612 (34.0)
No	1181 (65.7)
Perceived neighborhood environments	
Overall score	3.99 $\pm$ 0.66
Domain-specific score	
Outdoor spaces and buildings	4.11 $\pm$ 0.76
Transportation	4.36 $\pm$ 0.73
Housing	3.83 $\pm$ 1.02

Table 1 (continued)

Variable	Mean $\pm$ SD, n (%) ^a
Social participation	4.02 $\pm$ 1.07
Respect and social inclusion	3.86 $\pm$ 0.93
Civic participation and employment	3.60 $\pm$ 1.08
Communication and information	3.97 $\pm$ 0.89
Community support and health services	3.58 $\pm$ 0.91
Sense of community	
Total score	30.24 $\pm$ 5.07
Domain-specific score	
Needs fulfillment	7.14 $\pm$ 1.79
Group membership	8.20 $\pm$ 1.51
Influence	6.97 $\pm$ 1.68
Emotional connection	7.91 $\pm$ 1.51
Self-rated health	
Poor	209 (11.6)
Fair	854 (47.5)
Good	378 (21.0)
Very good	235 (13.1)
Excellent	120 (6.7)

^aPercentages may not total 100 due to missing data

(model 4, Table 3) had little effect on the results. The correlations of the demographic, socioeconomic, and environmental characteristics with perceived neighborhood environments, sense of community, and self-rated health are shown in Supplementary Table 1.

Table 4 shows the results of logistic regression models linking sense of community and self-rated health. In model 1, sense of community total score (OR 1.03, 95% CI, 1.01–1.05) and its domain-specific scores including “needs fulfillment” (OR 1.1, 95% CI 1.04–1.15), “influence” (OR 1.1, 95% CI 1.01–1.13), and “emotional connection” (OR 1.1, 95% CI 1.01–1.15) were positively associated with self-rated health. After adjustments for demographic, socioeconomic, and environmental characteristics, the results remained unchanged (model 4, Table 4).

Table 5 shows the results of linear regression models linking perceived neighborhood environments and sense of community. In the final model, perceived neighborhood environments overall score and its domain-specific scores were positively associated with sense of community total score (all $p < 0.001$). “Transportation” (unstandardized regression coefficients 2.8; $p < 0.001$) and “respect and social inclusion” (unstandardized regression coefficient 2.6; $p < 0.001$) were the physical and the social environmental

Table 2 Inter-correlation matrix of perceived neighborhood environments, sense of community, and self-rated health

Perceived neighborhood environments	Sense of community					Self-rated health
	Total	Needs fulfillment	Group membership	Influence	Emotional connection	
Overall score	0.536***	0.473***	0.323***	0.435***	0.391***	0.089***
Domain-specific score						
Outdoor spaces and buildings	0.370***	0.365***	0.240***	0.257***	0.258***	0.098***
Transportation	0.412***	0.355***	0.266***	0.316***	0.317***	0.067**
Housing	0.333***	0.292***	0.195***	0.279***	0.258***	0.094***
Social participation	0.410***	0.337***	0.266***	0.343***	0.301***	0.039
Respect and social inclusion	0.439***	0.378***	0.252***	0.383***	0.329***	0.080**
Civic participation and employment	0.346***	0.281***	0.197***	0.323***	0.271***	0.044
Communication and information	0.407***	0.345***	0.248***	0.355***	0.286***	0.049*
Community support and health services	0.439***	0.399***	0.244***	0.374***	0.314***	0.061*

Partial correlations adjust for age, sex, marital status, educational level, type of housing, length of residence, disposable income, economic activity status, and use of elderly community centers

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

domains most strongly associated with sense of community total score, respectively. When we separately examined the associations of the eight domains of perceived neighborhood environment with the four dimensions of sense of

community, “outdoor spaces and buildings” was the physical domain most strongly associated with “needs fulfillment”, while “transportation” was the physical domain most strongly associated with “group membership”,

Table 3 Effects of perceived neighborhood environment on self-rated health

Perceived neighborhood environments	Self-rated health							
	Model 1		Model 2 ^a		Model 3 ^b		Model 4 ^c	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Overall score	1.169	(1.01, 1.35)	1.257	(1.09, 1.46)	1.212	(1.04, 1.42)	1.263	(1.08, 1.48)
Domain-specific score								
Outdoor spaces and buildings	1.182	(1.04, 1.34)	1.249	(1.10, 1.42)	1.223	(1.07, 1.40)	1.266	(1.10, 1.46)
Transportation	1.050	(0.92, 1.19)	1.094	(0.96, 1.25)	1.066	(0.93, 1.23)	1.095	(0.95, 1.26)
Housing	1.213	(1.10, 1.33)	1.241	(1.13, 1.37)	1.194	(1.08, 1.32)	1.221	(1.10, 1.36)
Social participation	1.039	(0.95, 1.14)	1.086	(0.99, 1.19)	1.077	(0.98, 1.19)	1.094	(0.99, 1.21)
Respect and social inclusion	1.083	(0.98, 1.20)	1.146	(1.03, 1.27)	1.143	(1.02, 1.28)	1.165	(1.04, 1.31)
Civic participation and employment	1.060	(0.97, 1.16)	1.092	(1.00, 1.20)	1.069	(0.97, 1.18)	1.079	(0.98, 1.19)
Communication and information	1.050	(0.94, 1.17)	1.077	(0.97, 1.20)	1.036	(0.93, 1.16)	1.047	(0.93, 1.18)
Community support and health services	1.081	(0.97, 1.20)	1.117	(1.00, 1.24)	1.092	(0.98, 1.22)	1.125	(1.00, 1.26)

^a The model includes demographic characteristics (age and sex)

^b The model includes demographic characteristics (age and sex) and socioeconomic characteristics (marital status, educational level, disposable income, and economic activity status)

^c The model includes demographic characteristics (age and sex), socioeconomic characteristics (marital status, educational level, disposable income, and economic activity status), and environmental characteristics (physical: type of housing and length of residence, social: use of elderly community centers)

Table 4 Effects of sense of community on self-rated health

Sense of community	Self-rated health							
	Model 1		Model 2 ^a		Model 3 ^b		Model 4 ^c	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Total score	1.031	(1.01, 1.05)	1.040	(1.02, 1.06)	1.033	(1.01, 1.06)	1.035	(1.01, 1.06)
Domain-specific score								
Needs fulfillment	1.093	(1.04, 1.15)	1.121	(1.06, 1.19)	1.096	(1.03, 1.16)	1.107	(1.04, 1.18)
Group membership	1.061	(0.99, 1.13)	1.078	(1.01, 1.15)	1.064	(0.99, 1.14)	1.068	(0.99, 1.14)
Influence	1.070	(1.01, 1.13)	1.086	(1.02, 1.15)	1.070	(1.00, 1.14)	1.071	(1.01, 1.14)
Emotional connection	1.077	(1.01, 1.15)	1.103	(1.03, 1.18)	1.097	(1.02, 1.18)	1.107	(1.03, 1.19)

^a The model includes demographic characteristics (age and sex)

^b The model includes demographic characteristics (age and sex) and socioeconomic characteristics (marital status, educational level, disposable income, and economic activity status)

^c The model includes demographic characteristics (age and sex), socioeconomic characteristics (marital status, educational level, disposable income, and economic activity status), and environmental characteristics (physical: type of housing and length of residence, social: use of elderly community centers)

“influence”, and “emotional connection”. Among the social domains, “respect and social inclusion” was the most strongly associated with all dimensions of sense of community (data not shown).

Results of the path analyses examining the direct and indirect effects of perceived neighborhood environments and sense of community on self-rated health show significant direct effect of perceived physical environment on perceived social environment. Perceived physical environment directly affected self-rated health and indirectly through sense of community, whereas perceived social environment affected self-rated health through sense of community. The magnitude of the indirect effect of perceived social environment on self-rated health was more pronounced than that of perceived physical environment. The direct effect of perceived social environment on sense of community was larger than that of perceived physical environment. Sense of community alone also exerted direct effect on self-rated health, with a magnitude comparable to that of perceived physical environment (Fig. 2). Positive correlations were also found among the eight domains of perceived neighborhood environment (Supplementary Table 2).

Discussion

Although sense of community has been one of the most studied topics in community psychology, no empirical

study to date has examined the inter-relationships between perceptions of neighborhood environment, sense of community, and self-rated health in community-dwelling older Chinese people. The present study shows that perceptions of neighborhood environment, sense of community, and self-rated health were inter-related, whereas “transportation” and “respect and social inclusion” were the physical and the social environmental domains most strongly associated with sense of community, respectively. Results from the path analyses also suggest that sense of community directly affected self-rated health. Furthermore, sense of community accounted for part of the relationship between perceptions of neighborhood environment and self-rated health.

The present study extends the results from a previous study showing that perceptions of neighborhood environment were associated with self-rated health [35], reinforcing the importance of including a broad range of environmental attributes when examining potential correlates and determinants of health and well-being in older populations. Furthermore, sense of community was positively associated with self-rated health, suggesting that social factors, particularly the relationship between the individual and the social structure, are also pertinent to health and well-being of older people. This finding is consistent with previous studies showing positive relationships of sense of community with health and well-being [10–14, 38]. There are a number of possible explanations for the relationships found. In part, these

Table 5 Effects of perceived neighborhood environments on sense of community

Perceived neighborhood environments	Sense of community							
	Model 1		Model 2 ^a		Model 3 ^b		Model 4 ^c	
	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>	<i>B</i>	<i>p</i>
Overall score	4.465	< 0.001	4.431	< 0.001	4.297	< 0.001	4.334	< 0.001
Domain-specific score								
Outdoor spaces and buildings	2.724	< 0.001	2.674	< 0.001	2.542	< 0.001	2.638	< 0.001
Transportation	2.956	< 0.001	2.916	< 0.001	2.760	< 0.001	2.824	< 0.001
Housing	1.922	< 0.001	1.893	< 0.001	1.785	< 0.001	1.787	< 0.001
Social participation	2.109	< 0.001	2.086	< 0.001	1.972	< 0.001	1.948	< 0.001
Respect and social inclusion	2.728	< 0.001	2.702	< 0.001	2.596	< 0.001	2.575	< 0.001
Civic participation and employment	1.902	< 0.001	1.889	< 0.001	1.793	< 0.001	1.765	< 0.001
Communication and information	2.579	< 0.001	2.586	< 0.001	2.471	< 0.001	2.436	< 0.001
Community support and health services	2.730	< 0.001	2.694	< 0.001	2.590	< 0.001	2.567	< 0.001

^a The model includes demographic characteristics (age and sex), using enter procedure

^b The model includes demographic characteristics (age and sex) and socioeconomic characteristics (marital status, educational level, disposable income, and economic activity status), using enter procedure

^c The model includes demographic characteristics (age and sex), socioeconomic characteristics (marital status, educational level, disposable income, and economic activity status), and environmental characteristics (physical: type of housing and length of residence, social: use of elderly community centers), using enter procedure

relationships can be interpreted with respect to the idea of social capital, a concept referring to the properties of a community, which has been related to the sense of belonging and health [39]. For example, people with shared cultures and experiences are likely to form a community network or a meaningful social group of mutually helpful relationships, providing emotional support to others, which in turn may enhance self-rated health [40].

Given the importance of sense of community on self-rated health, identifying factors associated with sense of community is necessary. The present study found that higher levels of overall and domain-specific perceived neighborhood environments scores were associated with greater sense of community. Among the eight AFC domains, “transportation” and “respect and social inclusion” were the physical and the social environmental domains the most strongly associated with sense of community, respectively, after adjusting for covariates. When we separately examined the associations between perceived neighborhood environment domains and sense of community domains, we found that “respect and social inclusion” was the domain the most strongly associated with all dimensions of sense of community. These findings were supported by the results of the path analyses showing that sense of community accounted

for part of the relationship between perceptions of neighborhood environment, particularly the social domain, and self-rated health. A previous study also reported that social elements provided more explanation for sense of community than environmental elements [41]. A possible explanation may be that people who perceived their neighborhood environments as age-friendly are socially included, have greater access to health services and information, and are more likely to participate in community activities, which may facilitate social interaction, improve self-esteem, and, in turn, is likely to result in a greater sense of community. A prior cross-sectional study has also demonstrated a mediating role of sense of community on the relationship between perceived neighborhood environments and subjective well-being in terms of life satisfaction, meaning in life, positive affect, and negative affect in older people in China [42].

Although this study underscores the importance of sense of community for understanding the impact of social environment perceptions on self-rated health, perceptions of the physical environment also contributed to the enhancement of a sense of community, which in turn exerted an impact on self-rated health. Among the physical domains of perceived neighborhood environment, “outdoor spaces and buildings”

Fig. 2 Path diagram of the relationships among perceived neighborhood environments, sense of community and self-rated health. * $p < 0.05$, ** $p < 0.001$

was the most strongly associated with “needs fulfillment”, while “transportation” was the most strongly associated with “group membership”, “influence”, and “emotional connection”. Results of the path analyses also show a direct effect of perceived physical environment on self-rated health and an indirect effect on self-rated health through sense of community. These findings reaffirm the importance of perceptions of the built environment to self-rated health and highlight the role of the built environment on the development of sense of community. This is consistent with prior studies which indicated significant associations of urban design and perceptions of neighborhood (e.g., the presence of interesting sites and steep hills) with sense of community [27, 28, 43].

Results of the path analyses also revealed that perceptions of the physical environment directly affected perceptions of the social environment. Analyses of our data also found positive correlations among the eight domains of perceived neighborhood environment. These results are not unexpected and are consistent with earlier findings, suggesting that built environment characteristics influence perceptions of the social environment by encouraging social interactions [44]. Therefore, attempts to improve neighborhood conditions (e.g., by preserving parks and enhancing public transportation) may also be potential promising approaches to improve sense of community and self-rated health. In Hong Kong, parks are important meeting places in the neighborhood, providing opportunities for proximity to others, exercise, social interactions, and also passive social contact, which would increase the sense of community and self-rated health of older people. Having access to transportation is also critical for older people to pursue day-to-day activities and to stay connected to family and friends, which facilitates social interaction, social participation, physical activity, and in turn promotes sense of community and improves self-rated health.

Taken as a whole, the findings suggest that sense of community is important to self-rated health of older people and acts as a mediator in the relationship between perceptions of neighborhood environment and self-rated health. These results are reminiscent of the findings of a recent global comparison of older people’s health, psychological well-being, and capability in 97 countries and territories, where Hong Kong is rated quite poorly in psychological well-being and social

connection compared to its Western counterparts [45]. Therefore, findings of the present study have revealed the need for promoting “AFC” and sense of community at neighborhood level. Greater attention to respect and social inclusion as an influence on self-rated health is also warranted. A systematic review revealed that interventions on respect and social inclusion, particularly intergenerational interventions, art and culture, and multi-activity interventions, may have an impact on psychological outcomes, well-being, subjective, and physical health of older people [46]. Nevertheless, the importance of perceptions of the physical environment to sense of community should not be underestimated as there may be interactions among the built environment, the social environment, health, and well-being among older people. Therefore, our study has implications for the ways in which neighborhoods could be planned and designed.

Important strength of the present study includes the comprehensive measurement of perceptions of neighborhood environment in a densely populated urban city which facilitated examination of relative associations between multiple facets of the neighborhood environments and sense of community. However, limitations of the present study must also be considered. First, the cross-sectional nature of the present study precluded establishing causality, whereas a bi-directional relationship between sense of community and self-rated health may exist. Second, we did not collect information regarding participants’ health conditions and physical activity, which are important correlates of self-rated health. Third, there was no objective measure of the neighborhood environment that may have limited detection of significant associations between the built environment and sense of community.

In conclusion, sense of community had an influence on self-rated health, whereas perceptions of neighborhood environment, particularly relative to the social domain of respect and social inclusion, were associated with greater sense of community among older Chinese people. These findings can help policymakers and planners design health and wellbeing promoting policies and better intervention programs. Further efforts that focus on improvement of the neighborhood environment and perceptions of the environment might be important in strengthening sense of community, health, and well-being of older people in this community.

Acknowledgements The Jockey Club Age-friendly City Project was supported by the Hong Kong Jockey Club Charities Trust. The authors thank the investigators, research associates and team members for the design, collection, collation, validation and management of the data used in this article. Further appreciation is extended to the participants for their contributions to the study.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

1. The World Health Organization. Global age-friendly cities: a guide. Geneva, Switzerland; 2007.
2. Gao JL, Fu H, Li J, Jia YN. Association between social and built environments and leisure-time physical activity among Chinese older adults—a multilevel analysis. *BMC Public Health*. 2015;15:317.
3. Barnett A, Cerin E, Zhang CJP, et al. Associations between the neighbourhood environment characteristics and physical activity in older adults with specific types of chronic conditions: the ALECS cross-sectional study. *Int J Behav Nutr Phys Act*. 2016;13:53.
4. Sallis JF, Cerin E, Conway TL, et al. Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study. *Lancet*. 2016;387(10034):2207–17.
5. Wen M, Hawkey LC, Cacioppo JT. Objective and perceived neighborhood environment, individual SES and psychosocial factors, and self-rated health: an analysis of older adults in Cook County, Illinois. *Soc Sci Med*. 2006;63(10):2575–90.
6. Sarason SB. *The psychological sense of community: prospects for a community psychology*. San Francisco: Jossey-Bass; 1974.
7. Mcmillan DW, Chavis DM. Sense of community—a definition and theory. *J Community Psychol*. 1986;14(1):6–23.
8. Talo C, Mannarini T, Rochira A. Sense of community and community participation: a meta-analytic review. *Soc Indic Res*. 2014;117(1):1–28.
9. Chavis DM, Wandersman A. Sense of Community in the Urban-Environment—a catalyst for participation and community-development. *Am J Community Psychol*. 1990;18(1):55–81.
10. Cramm JM, Nieboer AP. Relationships between frailty, neighborhood security, social cohesion and sense of belonging among community-dwelling older people. *Geriatr Gerontol Int*. 2013;13(3):759–63.
11. van Hooijdonk C, Droomers M, Deerenberg IM, Mackenbach JP, Kunst AE. The diversity in associations between community social capital and health per health outcome, population group and location studied. *Int J Epidemiol*. 2008;37(6):1384–92.
12. Prezza M, Amici M, Roberti T, Tedeschi G. Sense of community referred to the whole town: its relations with neighboring, loneliness, life satisfaction, and area of residence. *J Community Psychol*. 2001;29(1):29–52.
13. Davidson WB, Cotter PR. The relationship between sense of community and subjective well-being: a first look. *J Community Psychol*. 1991;19:246–53.
14. Young AF, Russell A, Powers JR. The sense of belonging to a neighbourhood: can it be measured and is it related to health and well being in older women? *Soc Sci Med*. 2004;59(12):2627–37.
15. Wiles JL, Allen RES, Palmer AJ, Hayman KJ, Keeling S, Kerse N. Older people and their social spaces: a study of well-being and attachment to place in Aotearoa New Zealand. *Soc Sci Med*. 2009;68(4):664–71.
16. Aiello A, Ardore RG, Scopelliti M. Neighbourhood planning improvement: physical attributes, cognitive and affective evaluation and activities in two neighbourhoods in Rome. *Eval Program Plann*. 2010;33(3):264–75.
17. McLaren S, Jude B, Hopes L, Sherritt T. Sense of belonging, stress and depression in rural-urban communities. *International Journal of Rural Psychology*. 2001;2(7):1–12.
18. Belue R, Taylor-Richardson KD, Lin JM, McClellan L, Hargreaves MK. Racial disparities in sense of community and health status: implications in community-based participatory interventions targeting chronic disease in African Americans. *J Ambul Care Manage*. 2006;29(2):112–24.
19. Davidson WB, Cotter PR, Stovall JG. Social predispositions for the development of sense of community. *Psychol Rep*. 1991;68(3):817–8.
20. Li WW, Hodgetts D, Ho E. Gardens, transitions and identity reconstruction among older Chinese immigrants to New Zealand. *J Health Psychol*. 2010;15(5):786–96.
21. James RN, Carswell AT, Sweaney AL. Sources of discontent residential satisfaction of tenants from an internet ratings site. *Environ Behav*. 2009;41(1):43–59.
22. Lu M. Determinants of residential satisfaction: ordered logit vs. regression models. *Growth Change*. 1999;30(2):264–87.
23. Obst P, Smith SG, Zinkiewicz L. An exploration of sense of community, part 3: dimensions and predictors of psychological sense of community in geographical communities. *J Community Psychol*. 2002;30(1):119–33.
24. Prezza M, Costantini S. Sense of community and life satisfaction: investigation in three different territorial contexts. *J Community Appl Soc Psychol*. 1998;8(3):181–94.
25. Atkinson R, Blandy S. Introduction: international perspectives on the new enclavism and the rise of gated communities. *Hous Stud*. 2005;20(2):177–86.
26. Zhang H, Shyng J. Study on the relationship between dwelling characteristics and residential function satisfaction—collective housing as examples. *Journal of Architecture (Taiwan)*. 2004;47:89–106.
27. French S, Wood L, Foster SA, Giles-Corti B, Frank L, Leamihan V. Sense of community and its association with the neighborhood built environment. *Environ Behav*. 2014;46(6):677–97.
28. Wood L, Frank LD, Giles-Corti B. Sense of community and its relationship with walking and neighborhood design. *Soc Sci Med*. 2010;70(9):1381–90.
29. Chipuer HM, Pretty GMH. A review of the sense of community index: current uses, factor structure, reliability, and further development. *J Community Psychol*. 1999;27(6):643–58.

30. Hou J, Sung N. Urban residents' sense of community in Taichung li-Ming community. *Journal of Architecture (Taiwan)*. 1998;24:51–65.
31. Mak WW, Cheung RY, Law LS. Sense of community in Hong Kong: relations with community-level characteristics and residents' well-being. *Am J Community Psychol*. 2009;44(1–2):80–92.
32. Li LH. The physical environment and a “sense of neighborhood” in residential communities in Hong Kong. *Prop Manag*. 2008;26(1):7–24.
33. Grundy E, Sloggett A. Health inequalities in the older population: the role of personal capital, social resources and socioeconomic circumstances. *Soc Sci Med*. 2003;56(5):935–47.
34. Chau PH, Gusmano MK, Cheng J, Cheung SH, Woo J. Social vulnerability index for the older people—Hong Kong and New York City as examples. *J Urban Health: Bull N Y Acad Med*. 2014;91(6):1048–64.
35. Wong M, Yu R, Woo J. Effects of perceived neighbourhood environments on self-rated health among community-dwelling older Chinese. *Int J Environ Res Public Health*. 2017;14(6).
36. The World Health Organization. *Checklist of essential features of age-friendly cities*. Geneva, Switzerland 2007.
37. Huang YN, Wong H. Impacts of sense of community and satisfaction with governmental recovery on psychological status of the Wenchuan earthquake survivors. *Soc Indic Res*. 2014;117(2):421–36.
38. Tang F, Chi I, Xu L, Dong X. Exploring relationships of psychological sense of community with self-rated health and depressive symptoms among older Chinese Americans. *Gerontol Geriatr Med*. 2018;4:2333721418778183.
39. Fiorillo D, Lavadera GL, Nappo N. Social participation and self-rated psychological health: a longitudinal study on BHPS. *SSM Popul Health*. 2017;3:266–74.
40. Krause N. Providing emotional support to others, self-esteem, and self-rated health. *Arch Gerontol Geriatr*. 2016;65:183–91.
41. Moustafa YM. Design and neighborhood sense of community: an integrative and cross-culturally valid theoretical framework. *ArchNet-IJAR*. 2009;3(1):71–91.
42. Zhang Z, Zhang J. Perceived residential environment of neighborhood and subjective well-being among the elderly in China: a mediating role of sense of community. *J Environ Psychol*. 2017;51:82–94.
43. Lund H. Pedestrian environments and sense of community. *J Plan Educ Res*. 2002;21(3):301–12.
44. Brown SC, Mason CA, Lombard JL, et al. The relationship of built environment to perceived social support and psychological distress in Hispanic elders: the role of “eyes on the street.”. *J Gerontol Ser B Psychol Sci Soc Sci*. 2009;64(2):234–46.
45. CUHK Jockey Club Institute of Ageing. Report on agewatch index for Hong Kong 2015. *The Hong Kong Jockey Club*. Hong Kong, China; 2017.
46. Ronzi S, Orton L, Pope D, Valtorta NK, Bruce NG. What is the impact on health and wellbeing of interventions that foster respect and social inclusion in community-residing older adults? A systematic review of quantitative and qualitative studies. *Syst Rev*. 2018;7(1):26.